STABILITY RISK ASSESSMENT

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1.0 INTRODUCTION

1.1 Report Context

Mold Investments Limited (MIL) have instructed White Rock Geo Environmental Ltd to prepare an application for a bespoke Environmental Permit for a proposed inert landfill at their Parry's Quarry Site, Alltami, near Mold, Flintshire, CH7 6NZ.

The site's owners propose that the quarry void is restored by infilling with waste materials.

This SRA report addresses the stability of the proposed landfill considering four scenarios and makes recommendations based on the findings:

a. Global stability of Sidewall subgrade and liner
b. Veneer stability of the sidewall liner
c. Basal heave
d. Global stability of fill at the unconfined face

The site description, geology and hydrogeology have been taken from ESSD and HRA to which reference should be made for a more detailed treatment.

1.2 Site Location

The site is situated within the existing Parry's Quarry in Alltami, Flintshire and bounded by the A494 to the south, A55 to the north and Pinfold Road to the west. The National Grid Reference (NGR) for the entrance to the site is SJ 27478 66278, presented at Figure 1 below and is detailed at Drawing ESSD 1.

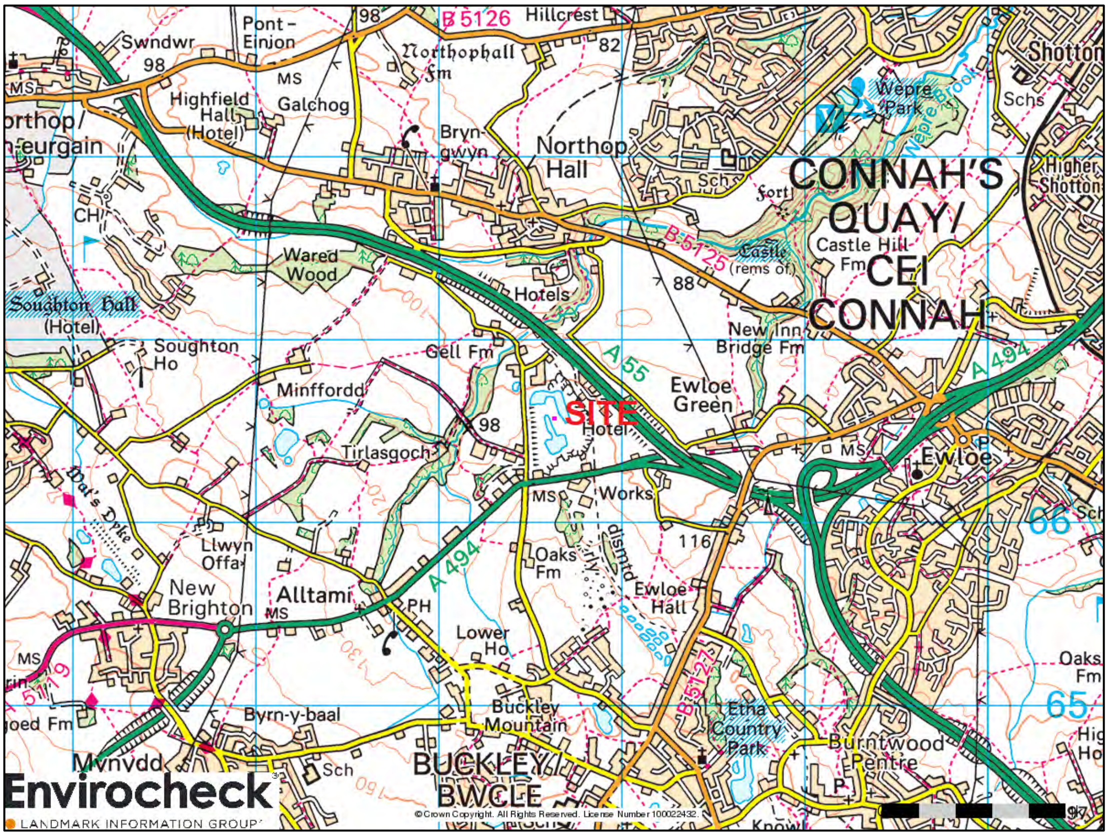
Access to the site is directly off Pinfold Lane through lockable steel security gates.

The site is currently operated as a brick clay quarry which covers an area of approximately 17 hectares. An area of the wider site holds an EP (Ref: EPR/TB3590HJ) for the transfer and reprocessing of inert waste. This EP application seeks to consolidate this activity within the overall landfill EP for the site.

The overall design is to now provide and engineering development platform using on site clays and crushed sandstone and the shortfall to be made up of imported inert waste which will then have a suitable engineering clean cover break over it which will comply with NHBC development protocols and requirements.

The site will be operated in two phases one based on hydraulic containment the second phase operated above the water table using an unsaturated zone to attenuate any pollution release beneath the geological barrier.

Figure 1: Site Location



1.3 Installation Details

The site is currently operated as a brick clay quarry which covers an area of approximately 17 hectares. An area of the wider site holds an EP (Ref: EPR/TB3590HJ) for the transfer and reprocessing of inert waste. This EP application seeks to consolidate this activity within the overall landfill EP for the site.

The proposed landfill operations will comprise the restoration of the quarry void space inert waste within fully engineered contained cells. The landfill will be below ground with the base of the cell and engineered containment being initially below the water table in Phase 1 and then raised above groundwater levels and Phase 2 will be operated above the water table.

The local topography is undulating and formed from a series of ridges and valleys. The site is situated at an elevation of circa 105mAOD on the site of the valley with the land to the south west riding up towards New Brighton at circa 145mAOD and falling away towards the north east towards the Wepre Brook, which is at an elevation of approximately 55mAOD. The wider topography is generally falling towards the River Dee Estuary which is at an elevation of circa 5mAOD approximately 4.5km to the north of site.

The permit application boundary is covered under the planning permission 04268 and the appeal APP/A6836/A/08/2068136.

Figure 2: Aerial view of site

The entire quarry perimeter is fenced with three strand barbed post and wire fence. The outer limit of the quarry has a hedgerow and tree planting. The site security fencing is considered adequate under the provisions of the Mines and Quarries Regulations 1999 in the location. The site has a substantial access to the site fitted with lockable gates. The site is within the entire ownership of Mold Investments Limited.

The gates at the site entrance are locked outside operating hours, and the site has offices and a wheelwash, inert treatment facility comprising a washing plant, mobile crusher and mobile screen.

All of the receptors have been identified on Drawing ESSD 2 and surrounding land uses are set out in Table ESSD1.

The site has an operational void capacity of 762,416m^3.

1.4 Proposed Development

This includes details relating to the following.

- The proposed waste types for the landfill area be inert non-reactive wastes which include Tax Qualifying Exempt Materials.

- A non-hazardous waste treatment facility will be operated to process construction and demolition wastes, other non-hazardous soils and to recovery secondary aggregates, which will also involve the use of crushers and screens and use of a barrel wash plant for road sweepings. The site will have a washing plant to process all excavated minerals. The detailed layout is presented at Drawing ESSD2.

- A skip will be located on site for load rejection.

- The site will have 2 operational phases to complete the landfill final landform. The time taken for all mineral extraction, lining, infilling and produce a development platform within 3 years.

- The site has valid planning permission until 2042.

- The final landform and end use is to create a development platform for commercial residential or commercial use.

- The site permit boundary requires an engineered geological barrier.

- Quarrying of clay and sandstone will continue across the site in tandem with inert landfill to complete the restoration of workings in a phased manner.

- The site is not within a Source Protection Zone and the site will be designed and operated on the principles of hydraulic containment.

- The proposed final landform is to form a surface with falls of approximately 1:20 which are suitable for residential and commercial development.

1.5 Installation Engineering

Groundwater Management System

Groundwater management is required during the operation of the site to ensure that groundwater is collected and directed to be removed during the infilling of Phase 1 and once above the rebound water table to stop pumping.

Basal Lining System

It is proposed to re-work the exposed Etruria Marl to form the geological barrier by rolling. The returned cores from the compaction trial and previous lining have shown less than 5% air voids.

The compaction trial of the Etruria Marl is presented at Appendix ESSD 2.

The Construction Quality Assurance Plan is presented at Appendix ESSD 3 detailing the method of construction and the standards and testing frequency.

The cells construction shall consist of a basal and side wall seal constructed above the prepared formation level from suitable low permeability material placed and compacted in layers. The thickness of mineral lining shall be a minimum of 1.0m.

The lining material shall be free of unsuitable material and a summary of the design specification is required to meet the following requirements:

i) Permeability ≤1 x10^{-7} m/s BS: 1377: 1990: Part 6: Method 6
ii) Plasticity Index <65% BS: 1377: 1990: Part 2: Methods 4.3 and 5.3
iii) Plasticity Index >10% BS: 1377: 1990: Part 2: Methods 4.3 and 5.3
iv) Clay Content (0.002mm) >8% BS: 1377: 1990: Part 2
v) Percentage Fines >20% BS: 1377: 1990: Part 2
vi) Maximum particle size >187mm* BS: 1377: 1990: Part 2
vii) Percentage Gravel(>5mm) ,≥30% BS: 1377: 1990: Part 2
viii)Liquid Limit <90% BS: 1377: 1990: Part 2: Methods 4.3 and 5.3
ix) Shear Strength >50kN/m^2 BS: 1377: 1990: Part 9

Side Slope Lining System

It is proposed to re-work the Etruria Marl to form the geological barrier side wall seal which will be placed in accordance with the Construction Quality Assurance Plan placed in 270mm-300mm layers and compacted as per the Highways Specification. The returned cores have shown less than 5% air voids.

The Construction Quality Assurance Plan is presented at Appendix ESSD 3 detailing the method of construction and the standards and testing frequency.

The cells construction shall consist of a side wall seal constructed above the prepared formation level from suitable low permeability material placed and compacted in layers. The thickness of mineral lining shall be a minimum of 1.0m.

The lining material shall be free of unsuitable material and a summary of the design specification is required to meet the following requirements:

i) Permeability ≤1 x10^{-7} m/s BS: 1377: 1990: Part 6: Method 6
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ix) Shear Strength >50kN/m^2 BS: 1377: 1990: Part 9

The side slope stability has been assessed as part of the Stability Risk Assessment for the permit application presented at Appendix C supporting the application.

Leachate Drainage System

A leachate drainage system is not required at an inert landfill site.

Capping System

An engineered capping system is not required at an inert landfill site.

2 HYDROGEOLOGICAL SETTING

Geology

The site is situated within an outcrop of Carboniferous aged Coal Measures strata (predominately comprising mudstones with sub-ordinate sandstones, siltstones and coal beds). The geological succession is complicated by local structural controls; which has created a series of fault bounded blocks in the area and caused the various types of bedrock to locally become juxtaposed against each other.

The geological sequence at the site has previously been described as very complex (TerraConsult[7], 2015); which is considered to reflect the rapid lateral and vertical changes in lithology due to the depositional nature of the sequence and post-depositional structural controls (i.e. dipping bedding and faulting). Attempts were made by TerraConsult to laterally correlate units observed at the site; evidently this was difficult due to the limitations of the available data (including that boreholes only provide a one-dimensional (vertical) record of the geological succession) and the complicated nature of the geology as outlined above. Nevertheless, based on published geological mapping, the following simplified geological sequence for local area has been identified:

- Etruria Formation[8] – comprising red, purple, brown, ochreous, green, grey and commonly mottled mudstone, with lenticular sandstones and conglomerates. The Etruria Formation includes the 'Buckley Blue' unit (a local and now obsolete name), which comprises a purple, black and grey mudstone, and was principally the clay that was excavated from the quarry void;

- Pennine Middle Coal Measures Formation – comprising inter-bedded grey mudstone, siltstone, pale grey sandstone and coal seams. The upper part of the Coal Measures includes a sandstone unit referred to as the 'Hollin Rock' which immediately underlies the Etruria Formation; and
- Pennie Lower Coal Measures Formation – comprising inter-bedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part.

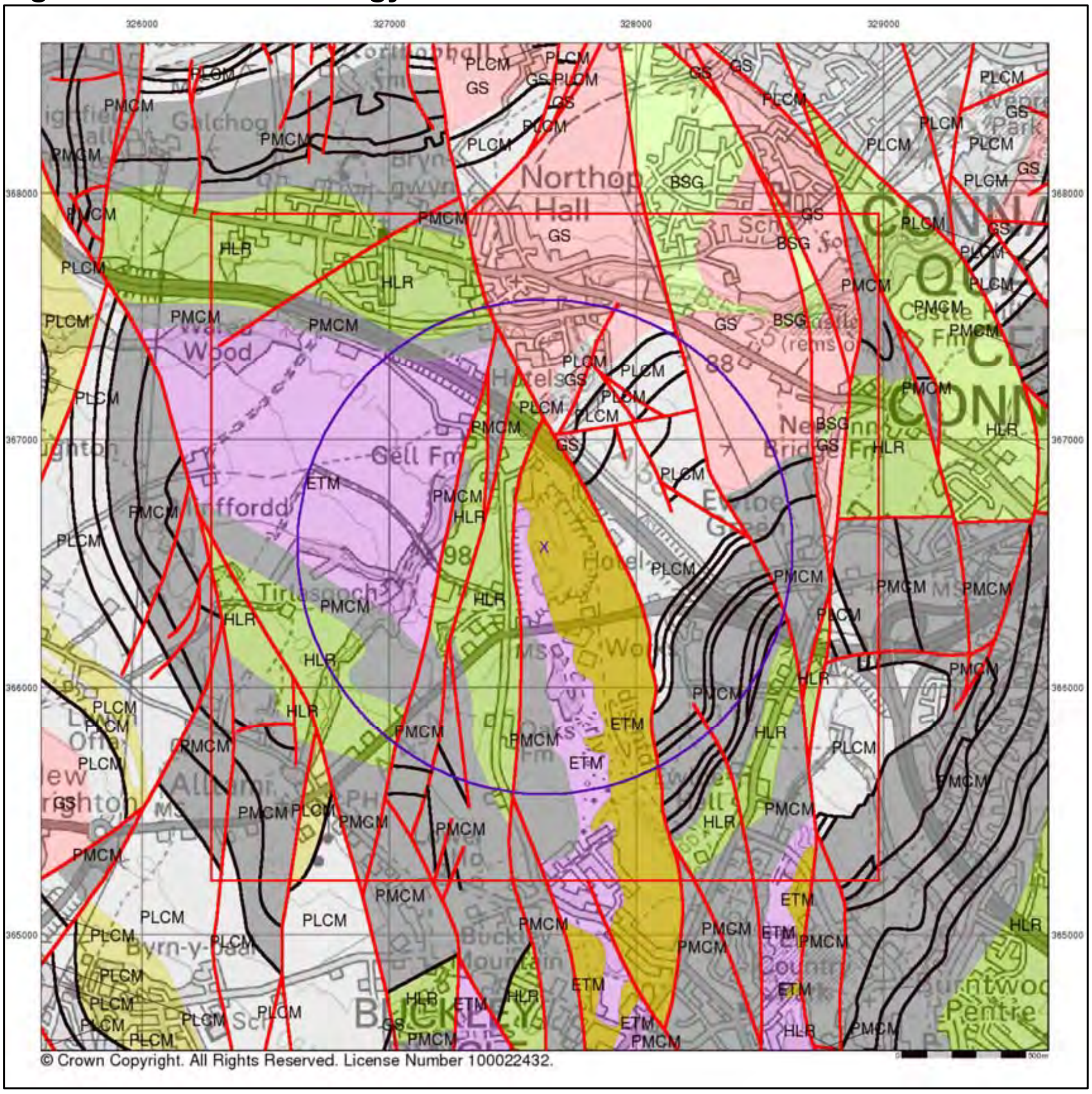
Available geological mapping (British Geological Survey (BGS) (2018), as shown on Drawing ESSD8, and at Figure 2 below indicates that sandstones of the Etruria Formation are present across the eastern two thirds of the Site (and extend to the area immediately to the east); mudstones, sandstones and conglomerates of the Etruria Formation are present across the western third of the Site. The Middle Coal Measures are then present further to the west. This includes the Hollin Rock Member which is identified beyond a north-south faulted boundary (with an apparent 50m downthrow) present along the western boundary of the Site. The Lower Coal Measures Formation are present c. 50m to the east of the Site beyond another approximately north-south faulted boundary.

Mapping of the superficial geology, as shown on Drawing ESID10, also shows that glacial till is present above bedrock across much of the area surrounding the site. The TerraConsult report shows that it is c. 2m in thickness and comprises a sandy clay with sandstone fragments. Superficial deposits are absent along the route of Alltami Brook where it is closets to the site (i.e. 250m to the northeast). Elsewhere however, alluvium is present along the course of the brook to the south (i.e. up-stream); and alluvium and glacio-fluvial (sand and gravel) deposits are present on both Alltami and Wepre brooks to the north (i.e. down-stream).

The mapping shows that superficial deposits are absent from across much of the site; this is due to the development that has taken place (i.e. initially a brickworks, followed by quarry extraction). Furthermore, the southern quarter of the site; the areas immediately to the north and to the south of the site; and several other areas in the vicinity are identified as artificial ground. Again, this

The Local bedrock geology is also presented at Figure 2 for reference below. The solid geological map is presented at Drawing ESSD 8 within the ESSD.

Figure 2: Bedrock Geology



Hydrology

The site lies within the catchment area of the River Dee. The nearest water course to the site is Alltami Brook which is situated to the west of the site; flowing from southwest to northeast. At its closest point it is 250m to the northwest of the site; it flows onwards and converges with Wepre Brook 700m to the north of the site. Wepre Brook flows from west to the east and is a tributary to the River Dee c. 4km to the northeast of the site. New Inn Brook, another tributary to Wepre Brook, is present 900m to the east of the site.

Identified flood risk zones associated with Wepre Brook and Alltami Brook are confined to their respective river channels and, as such, at their closest they are approximately 250m to the northeast of the site.

The area immediately to the south of the site includes several ponds and is part of the Deeside and Buckley Newt Sites designated SSSI and SAC. This relates to the presence of four protected amphibian species which were identified on the site mid-1990s. The owner of the site at that time (Hanson Brick Ltd) relocated these species from an area of planned mineral extraction and established a dedicated conservation area (which were subsequently designated as part of the SSSI and SAC).

Hydrogeology

Groundwater Flow

In general, the groundwater flow direction within the Coal Measures is expected to follow the overall topography towards the north; however local variations in flow directions (and hence piezometric head differences between separate or poorly connected hydrogeological units present within the Coal Measures) are also likely to be apparent.

TerraConsult (2015) previously undertook a detailed review of available groundwater level data at the site. However, limitations were recognised with the available data set including borehole records were not available for all monitoring points (i.e. so there was no knowledge of which hydrogeological units were being monitored); and rather than targeting discrete water bearing units, the groundwater monitoring points tended to have been installed with long response zones that intersect multiple, higher and lower, permeability units. As a result, the water levels may provide an ‘average’ water level for all the units; including some at higher elevations where groundwater flows may actually be negligible. Other limitations included the frequency and duration of available groundwater level monitoring data; and identifying the influence of groundwater dewatering that had been undertaken historically at the Site and in a neighbouring quarry.

For these reasons, it was decided that a new network of groundwater monitoring points was required at the site. This resulted in borehole drilling and the installation of 14 dedicated groundwater monitoring locations around the perimeter of the site in early 2017 (TerraConsult, 2017).

A programme of a groundwater level monitoring has been undertaken since these new groundwater monitoring points have been installed. The results are discussed in further detail in the HRA and are summarised below:

- The groundwater level monitoring that has been undertaken between January 2017 and November 2018 suggests that a relatively consistent piezometric surface is present which falls from c. 98 to 100mAOD in the south-east to c. 87 to 90mAOD in the west and north-west of the site.
- With the exception of one monitoring location (2016-C) the variation in groundwater levels that has been observed over this period is on average c. 2m but variations of up to a maximum of c. 4m have been identified.
- The recent groundwater monitoring data suggests that despite the identified small scale geological complexity, individual water bearing units appear to be relatively well connected at the scale of the site and so appear to combine to act as a single aquifer unit with a broadly consistent and identifiable piezometric surface across the site.

As described above, Alltami Brook, is located c. 250m to the north-west of the site. It is down topography from the site (where it is situated in a valley at an elevation of between c. 80 and 90mAOD; compared to the elevation of the site at around 110mAOD). Given that groundwater levels within the Coal Measures are typically between 87 and 90mAOD on the north-western boundary of the Site it is considered likely that there is hydraulic connection between groundwater and the brook down hydraulic gradient of the site (TerraConsult, 2015).

3.0 ANALYSIS APPROACH

This stability risk assessment (SRA) has been carried out in accordance with the principles of EuroCode 7, which uses a partial factor method (on actions and strength), to determine the Over Design Factor (ODF).

EuroCode 7 is based on the principles of limit state design, whereby a design must ensure that no limit state is exceeded. With respect to the analyses presented in this report, the limit state of relevance is limit state GEO defined as "*failure or excessive deformation of the ground, in which the strength of soil or rock is significant in providing resistance*", e.g. global stability of the landfill, bearing capacity of foundation soils.

Each limit state requires different partial factors to be used in the analysis. These are presented in the spreadsheet provided in Appendix B. It should be noted that the approach adopted in the UK for limit state GEO (Design Approach 1) requires two combinations of partial factors to be analysed as follows:

Combination 1 A1 + M1 + R1

Combination 2 A2 + M2 + R1

Where;
A = Partial factors on actions (applied forces and moments);
M = Partial factors on soil parameters; and
R = Partial factors on resistances.

The values of various sets of partial factors that are applied to characteristic actions (A1 and A2), characteristic material strengths (M1 and M2) and resistances (R1) vary depending upon whether they are favourable or unfavourable to the stability of the structure. Note: Only Combination 2 is considered in this assessment because any imposed loadings are negligible compared to the soil masses.

When considering a limit state of rupture or excessive deformation EuroCode 7 requires that $E_d \leq R_d$ where:

E_d = design value of effect of actions (forces) and
R_d = design value of the resistance to actions
The ratio R_d / E_d can be defined as the Over Design Factor and stability is demonstrated when the ODF ≥ 1.00. Hence, for each limit state considered, ODF's ≥ 1.00 are required for the construction to be considered stable (i.e. safe).

Computer Software

The analysis of global stability was undertaken using the computer programme *FLAC/Slope* (version 7), which utilises the finite difference method of analysis.

FLAC/Slope offers many advantages over traditional limit equilibrium based programmes.

i. Limit equilibrium codes use an approximate scheme (typically based on the method of slices) in which a number of assumptions are made (eg the location and angle of the interslice forces). Several assumed failure surfaces are tested (often many hundreds), and the one giving the lowest factor of safety is chosen. Equilibrium is only satisfied on an idealised set of surfaces.

ii. In contrast, *FLAC/Slope* provides a full solution of the coupled stress/displacement, equilibrium and constitutive equations. Given a set of properties, the system is determined to be stable or unstable. By automatically performing a series of simulations while changing the strength properties (strength reduction technique), the factor of safety (= ODF in these analyses) can be found to correspond to the point of stability and the critical failure (slip) surface can be located. Hence:

    1. Any failure mode develops naturally; there is no need to specify a range of trial surfaces in advance.
    2. No artificial parameters (eg functions for interslice force angles) need to be given as input.
    3. Multiple failure surfaces (or complex internal yielding) evolve naturally, if the conditions give rise to them.

The solution consists of mechanisms that are kinematically feasible whereas the limit equilibrium method considers only forces and not kinematics.

4.0 MATERIAL PROPERTIES

Soil/Rock Shear Strength

Material properties used in the slope stability analysis (using FLAC/Slope computer software) and assessment are discussed in detail below and a summary of the characteristic densities and shear strength parameters for the material types is presented in Table 1.

Short term (ie undrained) and long term (i.e. effective) strength parameters have been considered in the analyses.

The parameters listed in Table 1 represent the characteristic values selected for the stability assessment.

In accordance with EuroCode 7 partial factors have then been applied to obtain the design values for Combination 2 used which are also presented in Table 1. Note: Only Combination 2 is considered in this assessment of slope stability because any imposed loadings are negligible compared to the soil masses.

Inert Soils (CEDW)

The inert materials will be a mixture of demolition materials, construction excavation arisings etc and will sometimes be placed wet. Very conservative shear strength parameters have therefore been assumed for this material ie c_u = 30 kPa and c' = 0 and ϕ'= 25º.

Engineered Clay (Liners, Subgrades & bunds)

The Engineered Clay is understood to comprise reworked weathered mudstones ie sandy gravelly clays. Conservative characteristic shear strength parameters have been assumed for this material based on the Specification and TCL Experience ie c_u = 50 kPa and c' = 2.4 kPa and ϕ' = 24.55º.

Weathered Mudstone

The Weathered Mudstone has been assigned very conservative characteristic shear strength parameters based on Cripps & Taylor and Bell ie c_u = 140 kPa and c' = 50 kPa and ϕ' = 26º.

Table 1: EC7 Characteristic and Design Combination 2 material parameters

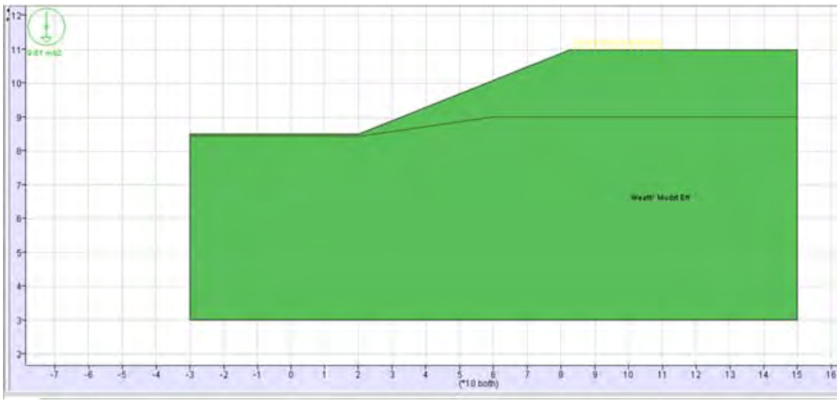
Material	EC7 Characteristic material parameters			EC7 Design Combination 2 material parameters			Unit weight (kN/m³)		Source
	Undrained	Effective stress		Undrained	Effective stress				
	$c_{u\,k}$ kPa	c'_k kPa	ϕ'_k deg	kPa	c'_{des} kPa	ϕ'_{des} deg	γ_d kPa	Sat'd γ_{sat} kPa	
Inert Waste (CEDW)							18	20	WRGE Experience
Engineered Clay (Liners, Subgrades & bunds)				35.7			17.5	19.5	Specification & WRGE Experience
Weathered Mudstone				100			22	23	Cripps & Taylor, Bell

5.0 GLOBAL STABILITY OF SIDEWALL SUBGRADE AND LINER

The section analysed was Section A derived from Drawing SRA1 (Engineering) Sections for Stability Risk Assessment**);** Section A being the longest side slope. The Flac section analysed is shown below.

Water levels were set at 90 m OD and a surcharge of 10 kPa was applied to the crest.

SECTION A



Analyses - Global Stability (GEO Limit State)
The outputs/results of the analyses are presented in Appendix A. In Appendix A the following should be considered when looking at the graphical outputs:

a. The X axis represents the distance along the section in m x 10.
b. The Y axis represents the reduced level of the various points in m x 10 at each distance along the section.
c. Unfortunately the units of strain contours cannot be plotted to a common scale as they are fixed by the software depending upon the range of strains produced. What the plot is used to show is where the critical failure (sliding) surface would be ie where the highest strains are concentrated.

The results of the analyses are summarised in Table 2.

Table 2 - ODFs for Global Stability of Sidewall Subgrade and Liner Section A

Section Run	**Over Design Factor**	**"Old BS" Factor of Safety (approx.)**	**Comment on analysis result**
A 01	1.02	1.43	Short term (Undrained) analysis. Critical slip surface deep through sideslope subgrade **SAFE**
A 02	1.72	2.15	Long term (Effective) analysis. Critical slip surface through toe of sideslope **Very SAFE**

Notes:

The factor of safety quoted on the FLAC/Slope output sheets is the EC7 ODF in these analyses.
To obtain the approximate Factor of Safety in effective stress analyses with no surcharge loadings the ODF is multiplied by 1.25.
To obtain the approximate Factor of Safety in undrained analyses in clay with no surcharge loadings the ODF is multiplied by 1.40.

Assessment and Recommendations

The Over Design Factor (ODF) is greater than 1.00 even with very conservative parameters and considering the entire subgrade to be highly weathered. The design is considered, therefore, to be safe.

6.0 BASAL HEAVE – UPLIFT LIMIT STATE

EC7 requires inequality 2.8 (EC7 page 33) to be verified to prove the stability of the system against failure by uplift (buoyancy) ie:

$G_{dst;d} + Q_{dst;d} \leq G_{stb;d} + R_d$
where

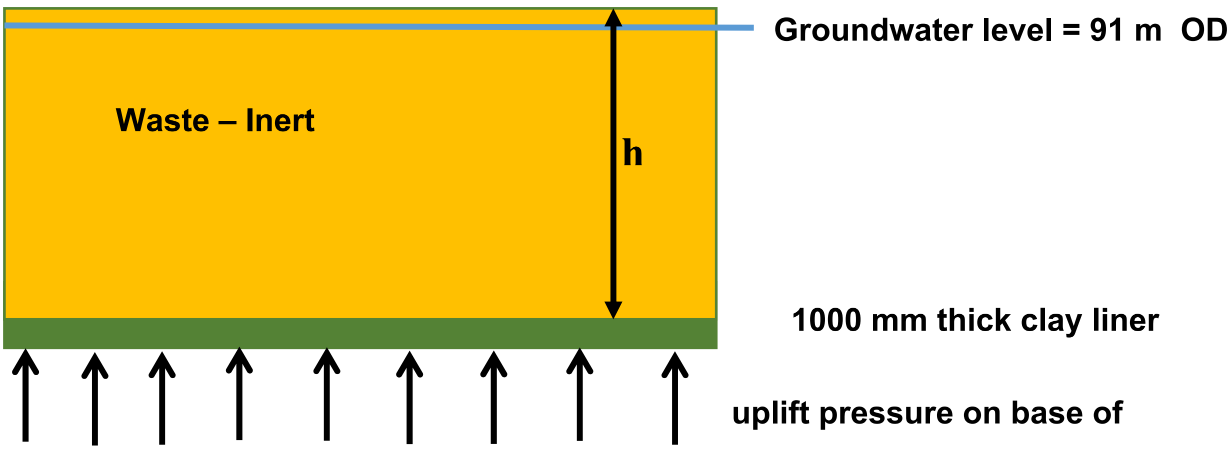
$G_{dst;d}$ = design value of destabilising permanent vertical action
$Q_{dst;d}$ = design value of destabilising variable vertical action
$G_{stb;d}$ = design value of stabilising permanent vertical action
R_d = design value of any additional resistance to uplift

The design value of an action = characteristic value * partial factor (EC7-Table A15)

Table A.15 - Partial factors on actions (γ_F)

Action	Symbol	Value
Permanent		
Unfavourable[a]	$\gamma_{G;dst}$	1,0
Favourable[b]	$\gamma_{G;stb}$	0,9
Variable		
Unfavourable[a]	$\gamma_{Q;dst}$	1,5
[a] Destabilising;		
[b] Stabilising		

The analysis uses the following diagram:



The analysis follows the following sequence:
For Phase 1.

Formation level = 90 m OD

Characteristic uplift pressure on base = (1-4)*9.81 = 9.81 kPa-39.24kPa
Design uplift pressure on base = 39.24*1.5 = 58.86 kPa

R_d = characteristic resistance from clay liner = 1.0*18 = 18.0 kPa
Design resistance from clay liner = 0.9*18.0 = 16.2 kPa

Design value of stabilising permanent vertical action (from waste)

= 10*h*1.8 = 18h

Hence for stability:

58.86 kPa ≤ 18h + 16.2 kPa

or h > (58.86 – 16.2)/18 = 2.37 therefore RL = 90 + 1.0+ 2.37 = 93.37 m OD

The results of the analyses are summarised in Table 1.

Table 3 – Waste levels to be achieved before cessation of pumping

Phase	waste levels to be achieved before cessation of pumping m OD
1	93.37
2	-

7.0 MONITORING

The Risk Based Monitoring Scheme

Based on the assessment in Sections 4 to 6 the following is considered;

Basal Sub-Grade Monitoring

Not applicable

Side Slopes Sub-Grade Monitoring

Visual inspection

Basal Lining System Monitoring

Monitor to ensure that levels reach 93.37m AOD in Phase 1 before switching off groundwater pumps.

Side Slope Lining System Monitoring

Shear vane testing and visual inspection.

Waste Mass Monitoring

Not applicable.

Capping System Monitoring

Not applicable.

REFERENCES

1. EuroCode 0 – BS EN 1990. Basis for Structural Design. BSI.

2. EuroCode 7 – BS EN 1997 (published in 2 parts). Geotechnical Design. BSI.

3. EuroCode 0 – NA to BS EN 1990: 2002. UK National Annex for Eurocode 0 – Basis of structural design.

4. EuroCode 7 – NA to BS EN 1997-1: 2004. UK National Annex to Eurocode 7: Geotechnical design – Part 1: General rules.

5. Environment Agency (2010), Earthworks in Landfill Engineering. Report LFE4, Environment Agency, Bristol.

6. Environment Agency (2003), Stability of Landfill Lining Systems: Report No. 1 Literature Review. R&D Technical report P1-385/TR1, Environment Agency, Bristol, pp 219.

7. Environment Agency (2002), Stability of Landfill Lining Systems: Report No. 2 Guidance. R&D Technical report P1-385/TR2, Environment Agency, Bristol, pp 170.

8. Cripps, J.C., and Taylor, R.K., (1981) The engineering properties of mudrocks, Q.J.eng.Geol.London, Vol. 14, pp. 325-346.

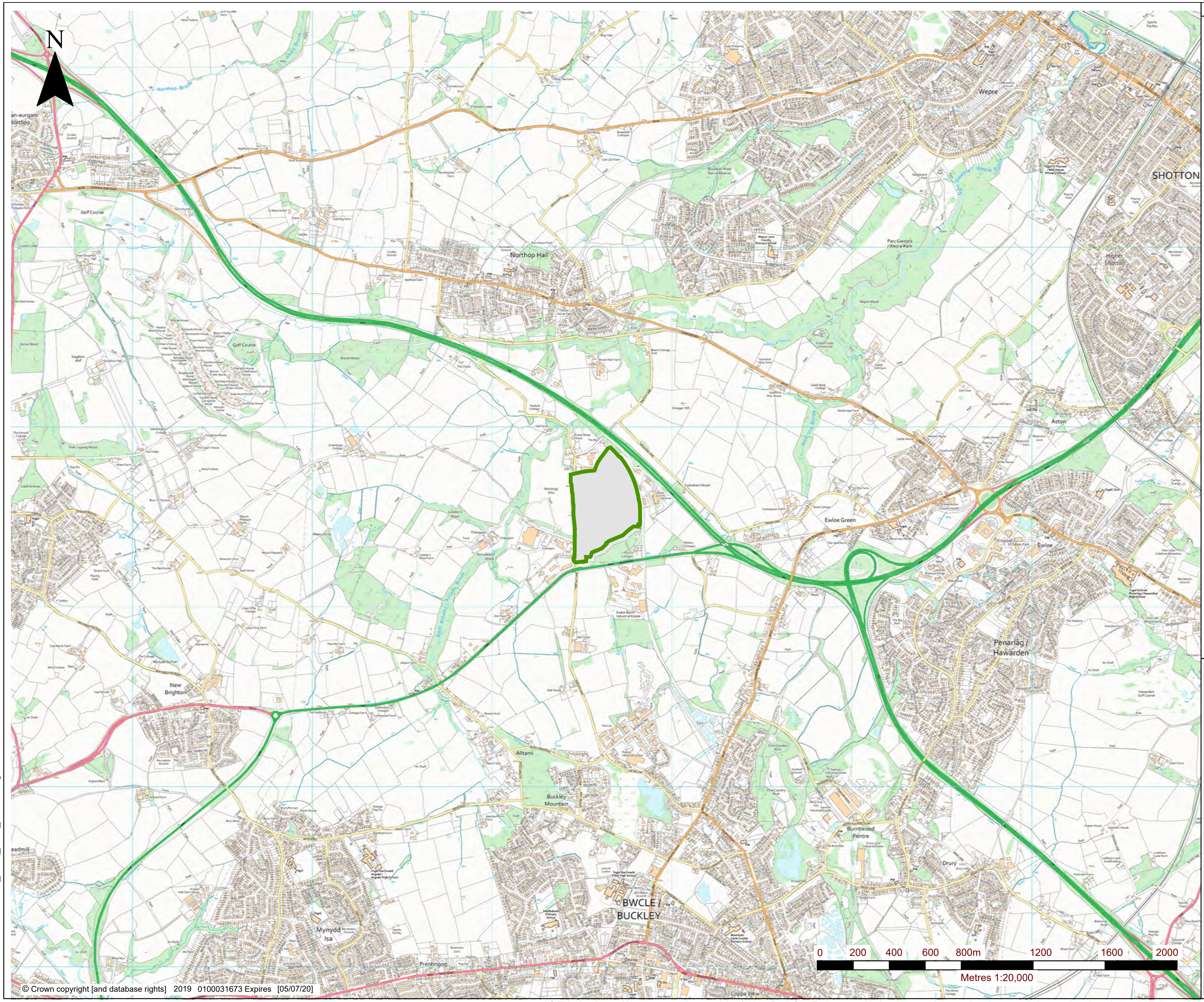
9. Bell, F.G., (2000) Engineering Properties of Soils and Rocks (4th Ed.), Blackwell Science, Oxford, 482 pp.

10. Jones and Dixon (1998), The stability of geosynthetic landfill lining systems, in 'Geotechnical engineering of landfills' Ed N, Dixon, E J Murray and D R V Jones 99-130 Thomas Telford: London.

11. Qian, X., Koerner, R. M. and Gray, D. H., (2002). Geotechnical Aspects of Landfill design and Construction. Prentice Hall, New Jersey, pp 717.

12. Dixon, N., Jones, D. R. V., and Fowmes G. J., (2006), Interface shear strength variability and its use in reliability-based landfill stability analysis, Geosynthetics International, 2006, Volume 13, No 1.

Drawings



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LEGEND

ENVIRONMENTAL PERMIT BOUNDARY

MOLD INVESTMENTS LTD

WHITE ROCK GEO-ENVIRONMENTAL LIMITED

PARRY'S QUARRY LANDFILL

ENVIRONMENTAL PERMIT APPLICATION

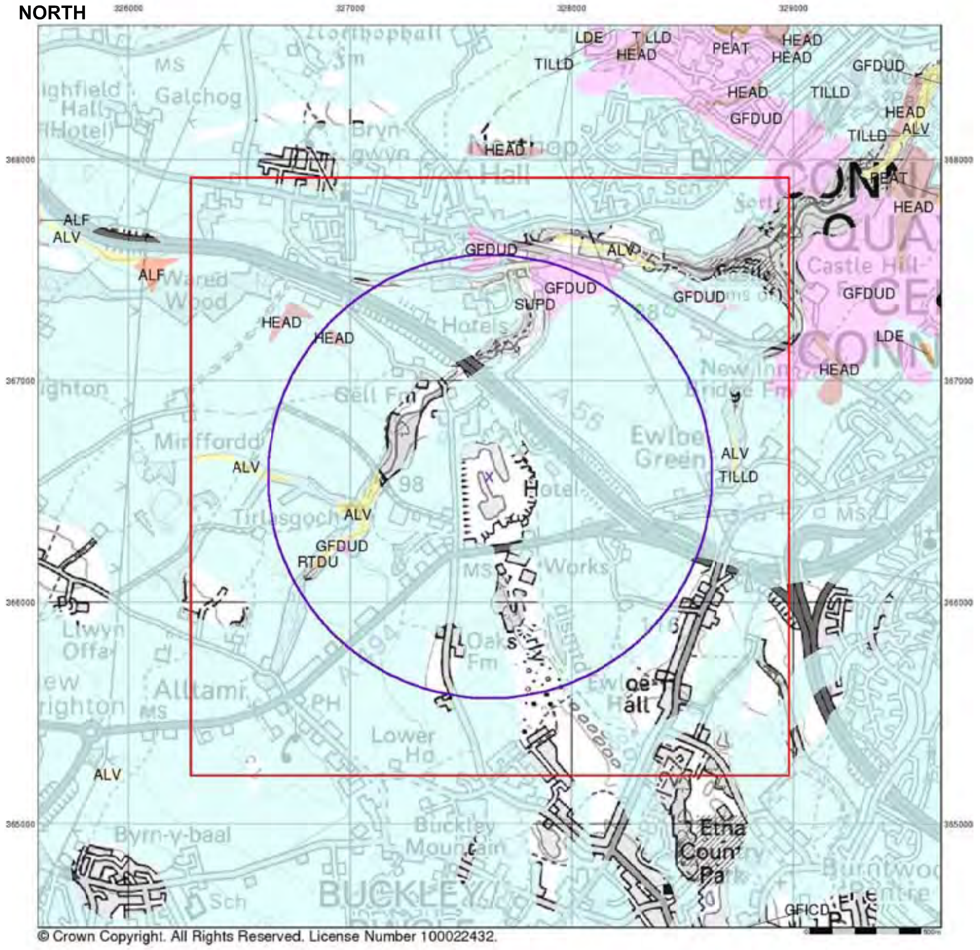
SITE LOCATION PLAN

ESSD1

Scale	Date
1:20,000 @ A3	JUNE 2020

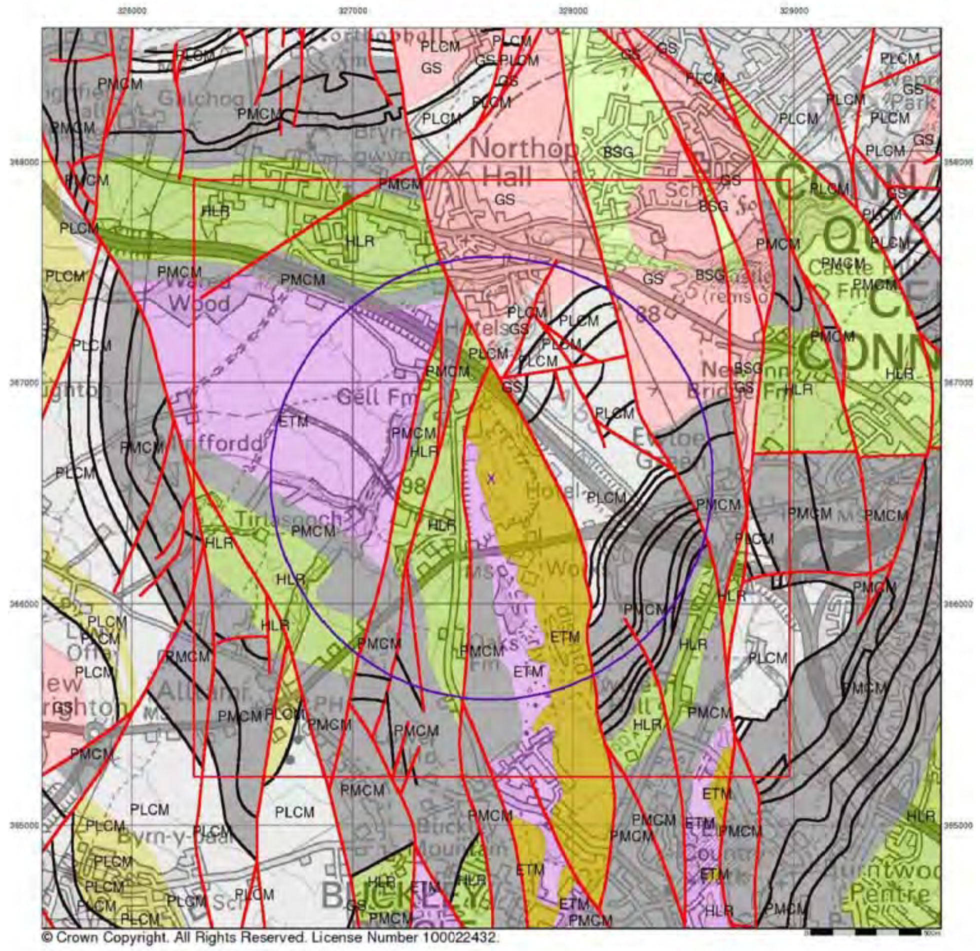
NORTH

Superficial Geology



Rock Type	LEX	Rock Name	Age	Rock Type	LEX	Rock Name	Age
Sand and Gravel	GFDUD	Glaciofluvial Deposits, Undifferentiated, Devensian	Devensian - Devensian	Clay, Silt, Sand and Gravel	GFDUD	Head (Undifferentiated)	Quaternary - Quaternary
Diamicton	TILLD	Till, Devensian	Devansian - Devanisan	Sand and Gravel	TILLD	River Terrace Deposits (Undifferentiated)	Quaternary - Quaternary
Clay, Silt, Sand and Gravel	ALV	Alluvium	Quaternary - Quaternary	Unknown Lithology	ALV	Superficial Deposits (Undifferentiated)	Quaternary - Quaternary

Bedrock Geology



Rock Type	LEX	Rock Name	Age	Rock Type	LEX	Rock Name	Age
Mudstone, Siltstone and Sandstone	PLCM	Pennine Lower Coal Measures Formation	Langsettian - Langsettian	Mudstone, Siltstone and Sandstone	PMCM	Head (Undifferentiated)	Bolsovian - Durkmantian
Mudstone, Sandstone and Conglomerate	ETM	Etruria Formation	Westphalian - Westphalian	Sandstone	ETM	River Terrace Deposits (Undifferentiated)	Westphalian - Westphalian
Sandstone and [Subequal/subordinate] Argillaceous Rocks, interbedded	GS	Gwespyr Sandstone	Langsettian - Yeadonian	Sandstone	HLR	Superficial Deposits (Undifferentiated)	Bolsovian - Bolsovian

Legend

Client: **Mold Investments Ltd**

Project: **Parrys Quarry**

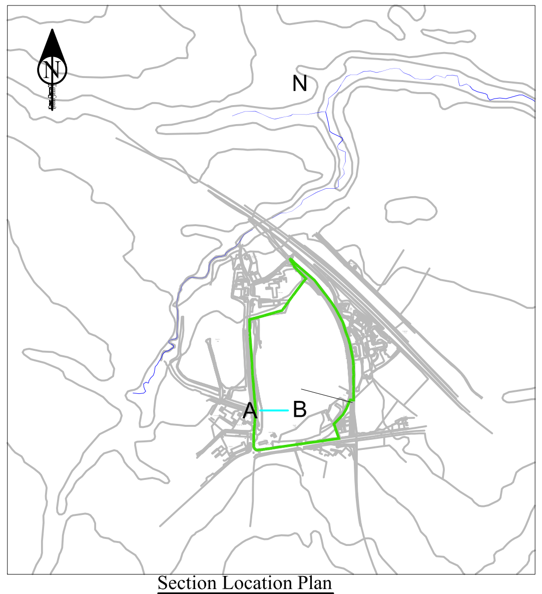
Title: Regional Geology

CAD Ref:	Version:	Drawn by:	Scale:	Date:
EL/MQBH/1	1	ARM		June 2020

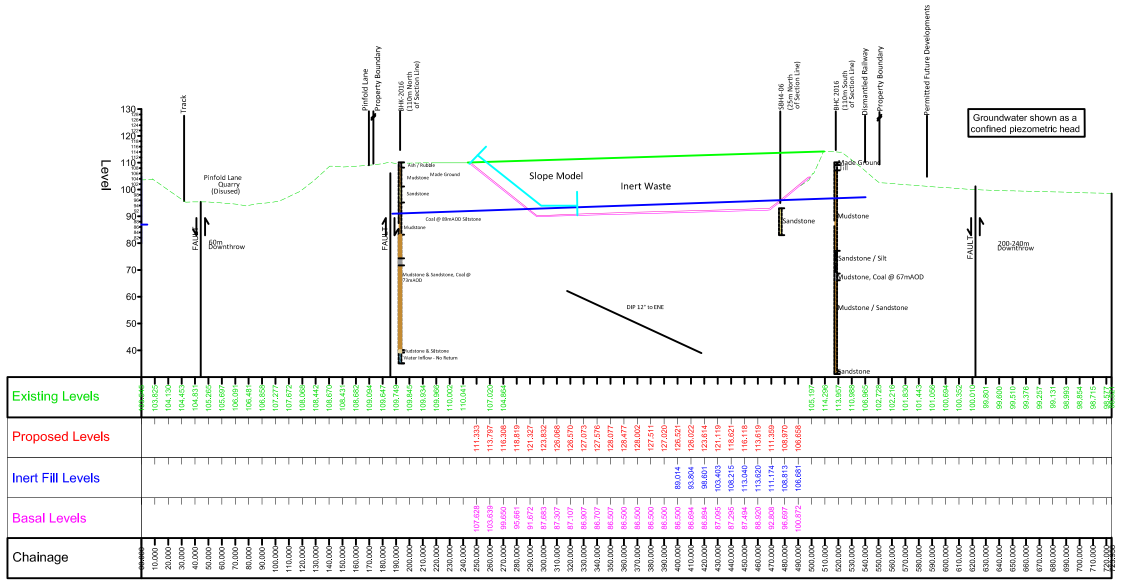
WHITE ROCK GEO-ENVIRONMENTAL LIMITED

Drawing: **ESSD8**

NORTH



Section Location Plan
Scale 1:10,000



West-East Section
Scale 1:2,000 Hz/1:1,000 Vt

Legend

Client: **Mold Investments Ltd**

Project: **Parrys Quarry**

Title: Stability Risk Assessment
Cross Section

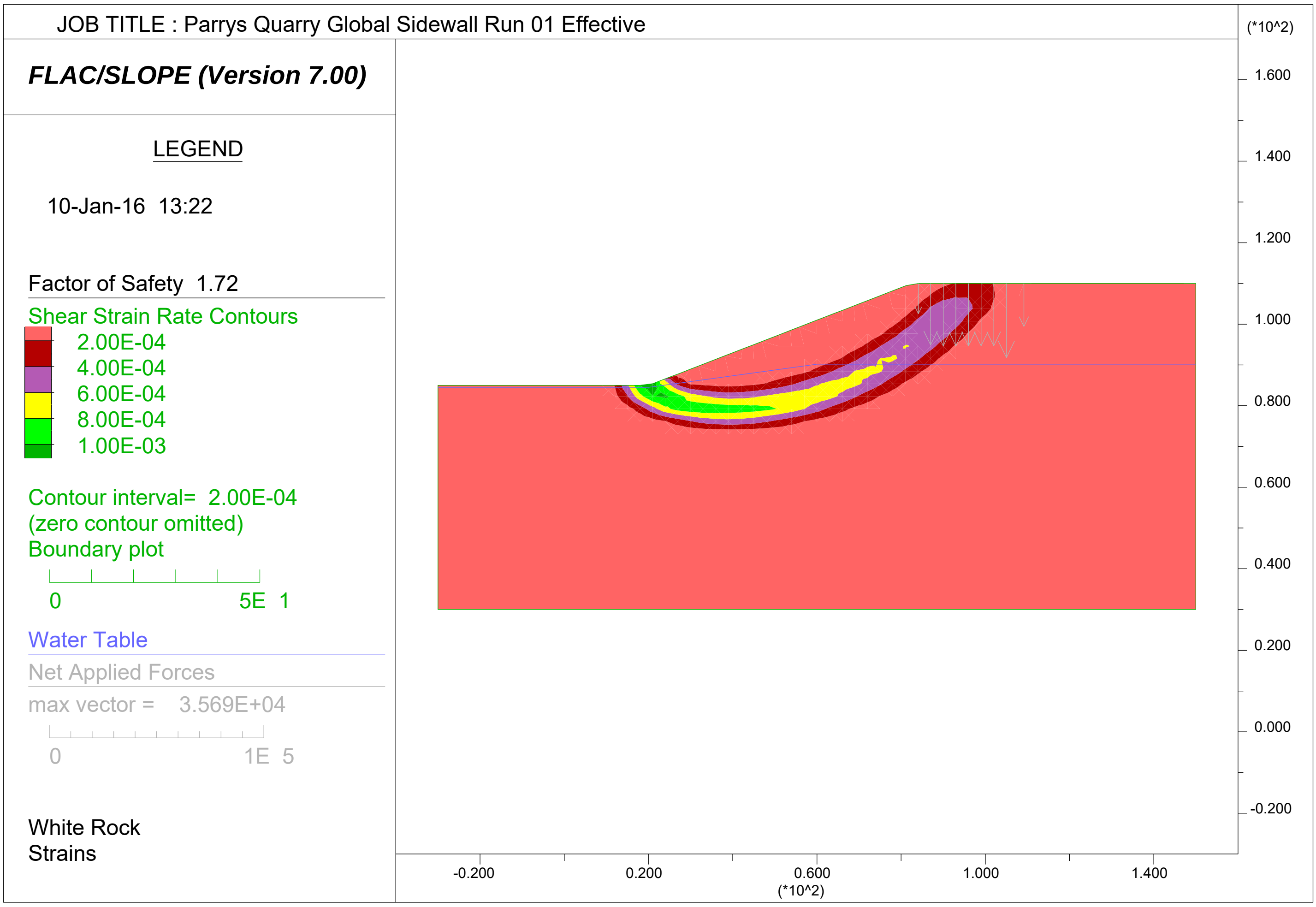
CAD Ref:	Version:	Drawn by:	Scale:	Date:
EL/QQSRA/1	1	ARM		June 2020

WHITE ROCK GEO-ENVIRONMENTAL LIMITED

Drawing: **SRA 1**

APPENDIX A:

Global Stabilty/FLAC Outputs


JOB TITLE : Parrys Quarry Global Sidewall Run 01 Effective
FLAC/SLOPE (Version 7.00)
LEGEND
10-Jan-16 13:22
Factor of Safety 1.72
Shear Strain Rate Contours
2.00E-04
4.00E-04
6.00E-04
8.00E-04
1.00E-03
Contour interval= 2.00E-04
(zero contour omitted)
Boundary plot
0
5E 1
Water Table
Net Applied Forces
max vector = 3.569E+04
0
1E 5
White Rock
Strains
(*10^2)
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.200
0.200
0.600
1.000
1.400
(*10^2)

JOB TITLE : Parrys Quarry Global Sidewall Run 01 Effective

FLAC/SLOPE (Version 7.00)

LEGEND

10-Jan-16 13:23

Factor of Safety 1.72

User-defined Groups

'Weathered Rock:Weath Mudst

Boundary plot

0 5E 1

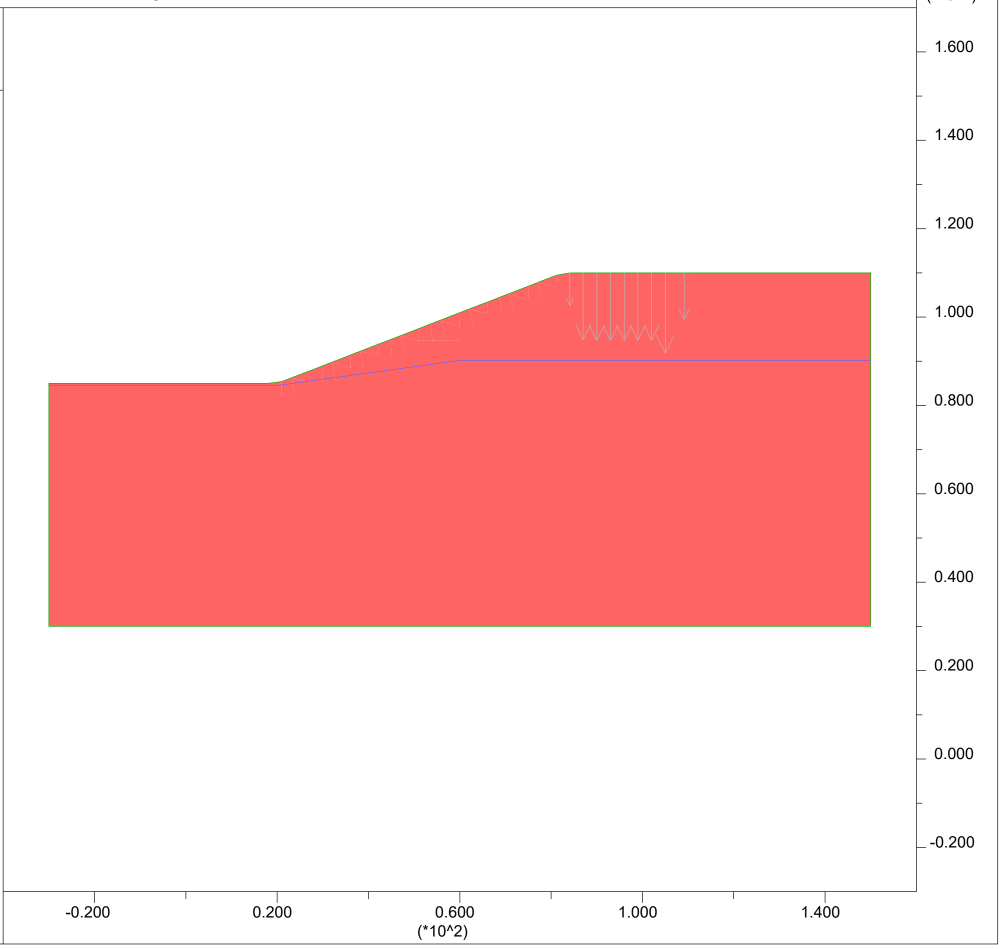
Water Table

Net Applied Forces

max vector = 3.569E+04

0 1E 5

White Rock
Materials



JOB TITLE : Parrys Quarry Global Sidewall Run 01 Undrained

FLAC/SLOPE (Version 7.00)

LEGEND

10-Jan-16 13:08

Factor of Safety 1.02

Shear Strain Rate Contours

- 5.00E-04
- 1.00E-03
- 1.50E-03
- 2.00E-03
- 2.50E-03
- 3.00E-03
- 3.50E-03

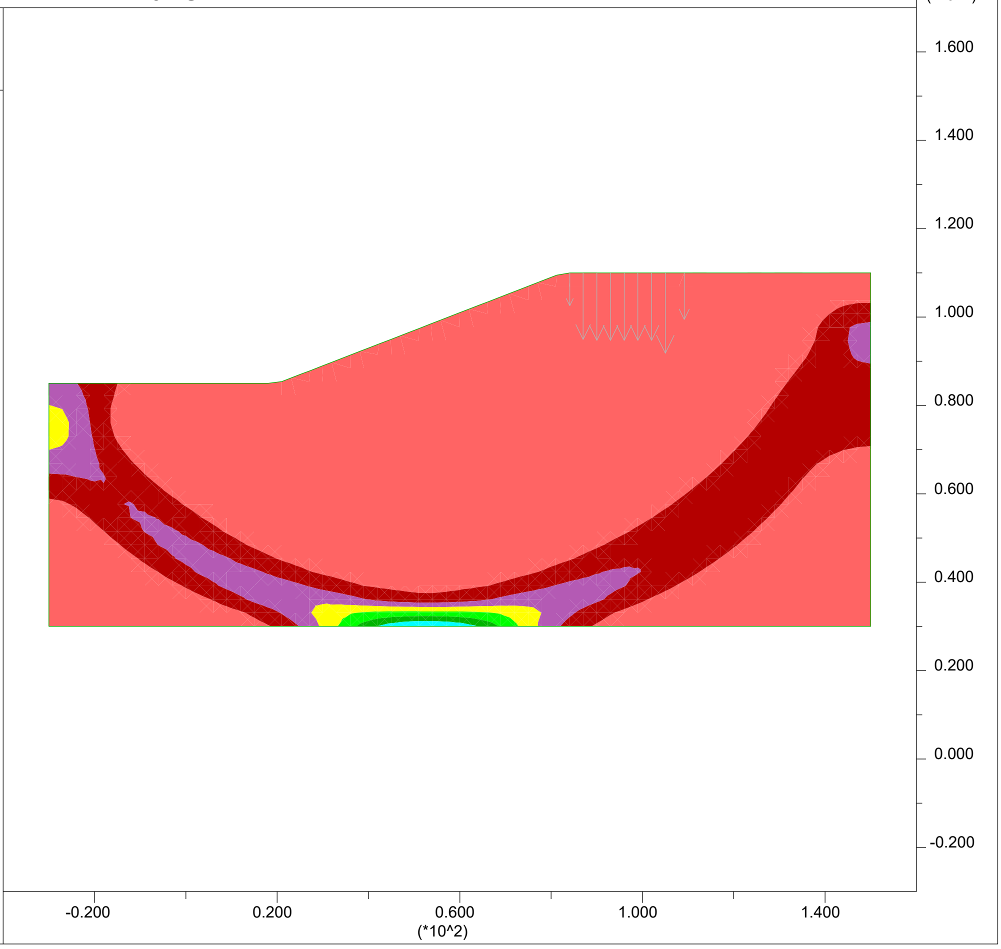
Contour interval= 5.00E-04
(zero contour omitted)
Boundary plot

0 5E 1

Net Applied Forces
max vector = 3.569E+04

0 1E 5

White Rock
Strains



JOB TITLE : Parrys Quarry Global Sidewall Run 01 Undrained

FLAC/SLOPE (Version 7.00)

LEGEND

10-Jan-16 13:06

Factor of Safety 1.02

User-defined Groups

'Weathered Rock:Weath Mudst

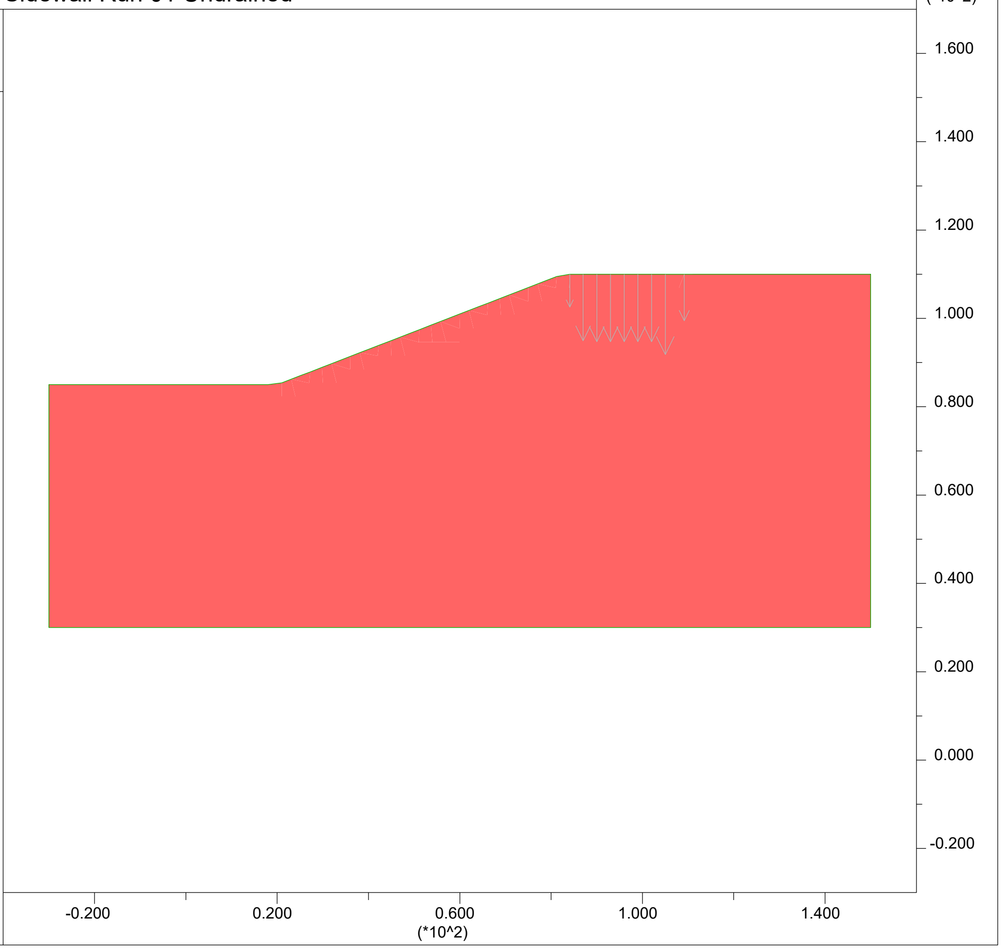
Boundary plot

0 5E 1

Net Applied Forces

max vector = 3.569E+04

0 1E 5



White Rock Materials